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ORIGINAL ARTICLE

Antibacterial and antioxidant properties of hesperidin: β-cyclodextrin complexes obtained by different techniques

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Abstract The purpose of this study was to investigate the influence of β-cyclodextrin on aqueous solubility of hesperidin. The inclusion complexes were prepared by different methods (kneading, co-evaporation and lyophilization) and were tested for their antimicrobial and antioxidant activities. Solubility diagrams were drawn at four temperatures (20, 25, 37 and 40 °C) and the corresponding stability constants were calculated. The solubility diagrams obtained were of A_L type and the stoichiometric ratio was 1:1. Moreover, the thermodynamic parameters of the complexation reaction were calculated: Gibbs free energy change, free energy change, enthalpy change and entropy change. The results showed that the complexation reaction is more effective with the increase in temperature and in cyclodextrin concentration. The inclusion process is endothermic and spontaneous and the interactions between hesperidin and β-cyclodextrin are hydrophobic. UV–Vis, FTIR, ^{1}HNMR, methods provided valuable information about complex formation. Antibacterial activity was investigated by the agar diffusion method, against *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and *Candida albicans* ATCC 10231. The results revealed that all the prepared compounds display a higher antibacterial activity compared to hesperidin. Also, the inclusion compounds presented an improved antioxidant activity, demonstrated by the determination of inhibition of lipoxygenase activity, DPPH radical scavenging activity and determination of reducing capacity. In vitro dissolution tests demonstrated that the inclusion compounds have an improved dissolution, compared to free hesperidin. The enhancement in the solubility, antibacterial and antioxidant activities depend on the method of preparation.

Keywords Hesperidin · β-cyclodextrin · Inclusion complex · Antibacterial capacity · Antioxidant capacity · In vitro dissolution profile

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Introduction

Hesperidin (HES) (Fig. 1a) is a naturally occurring flavanone glycoside which is found in citrus peel, used alone or in combination, as vascular-protecting agents, for treating chronic venous insufficiency, hemorrhoids, lymphedema, and varicose veins [1]. The HES presents antioxidant and anti-inflammatory properties [2], anti-proliferative and anti-cancer properties [3]. Also, HES significantly decreases the cholesterol levels, total lipids and triglycerides and may be used in the prevention of atherosclerosis and hypertension diseases [4]. Likewise, HES decreases the bone density loss [5] and manifests antinociceptive and sedative activity [6]. Due to its poor solubility in water, the administration is rather limited.

In this context, complexation of insoluble drugs with cyclodextrins, offers, without changing their original structures, the possibility to improve their aqueous solubility, stability to light and oxygen or smell removing, and may allow homogeneous drug delivery systems, increasing their bioavailability [7–11].

Cyclodextrins are cyclic oligosaccharides and are usually formed by 6, 7 or 8 glucose units, covalently bounded